Last class:
eg. An electron and positron annihilate. How much energy is given off?
mass of electron is 9.11×10^{-31}kg (same for positron).

$E=mc^2 = 2x(9.11x10^{-31}kg)x(3.00x10^{8}m/s)^2$
2x9.11x3x3=163.98
$= 1.64 \times 10^{-13}$J
2x9.11E-31x3E8x3E8=0.0
or 1MeV= 1.602×10^{-13}J

the energy released = 1.6398/1.602=1.0236
1.02MeV

mass of an electron 9.11×10^{-31}kg = $0.511MeV/c^2$ = 0.000549u

If 1 u of matter is changed into energy, how much is produced in MeV?
u is the atomic mass unit = 1/12 of the carbon-12 isotopic mass
1u = 1.66053904×10^{-27} kg
$E=mc^2 = 1.66053904x10^{-27}$ kg $(2.99792x10^{8}m/s)^2$
= 1.66053904x2.99792x2.99792=14.92413502
exponents: -27+8+8=-11

14.924×10^{-11}J = 1.4924×10^{-10}J
1MeV = 1.60218×10^{-13}J

1.4924×10^{-10}J/ 1.60218×10^{-13}J
1.4924/1.60218=0.93148
-10-(-13)=3
0.93148×10^{3}
931.48MeV per u annihilated

Binding Energy

We know that carbon-12 has an atomic mass of 12.000000000000000u (exactly)

but mass of a proton is 1.007825u
and the mass of a neutron is 1.008665u

Do you notice something?

the masses don't add up.
6 protons have a mass of 6x1.007825=6.04695
6 neutrons have a mass of 6x1.008665=6.05199
total mass 6.04695+6.05199=12.09894

but carbon-12 has a mass of exactly 12.

What's the deal?

Nuclear fusion happens in stars where Hydrogen and other small nuclei combine form larger nuclei.

Some of the mass is lost- mass defect.
The lost mass changes into energy.
Binding energy is the difference between mass of the protons and neutrons and the mass of the nucleus converted into energy. It is also the minimum energy required to pull the nucleus apart into protons and neutrons.

mass defect=mass of products - mass of reactants
=mass of isotope - (mass of protons+mass of neutrons)

eg. for Carbon-12
mass defect = 12-(6.04695+6.05199)=-0.09894 u

Binding energy
calculate the hard way $E=mc^2$
or use 931.48MeV per u annihilated factor

Binding energy = mass defect in u x 931.48MeV/u

eg. 0.09894x931.48=92.16063 =92.16MeV

Atoms with more binding energy/nucleon are more stable

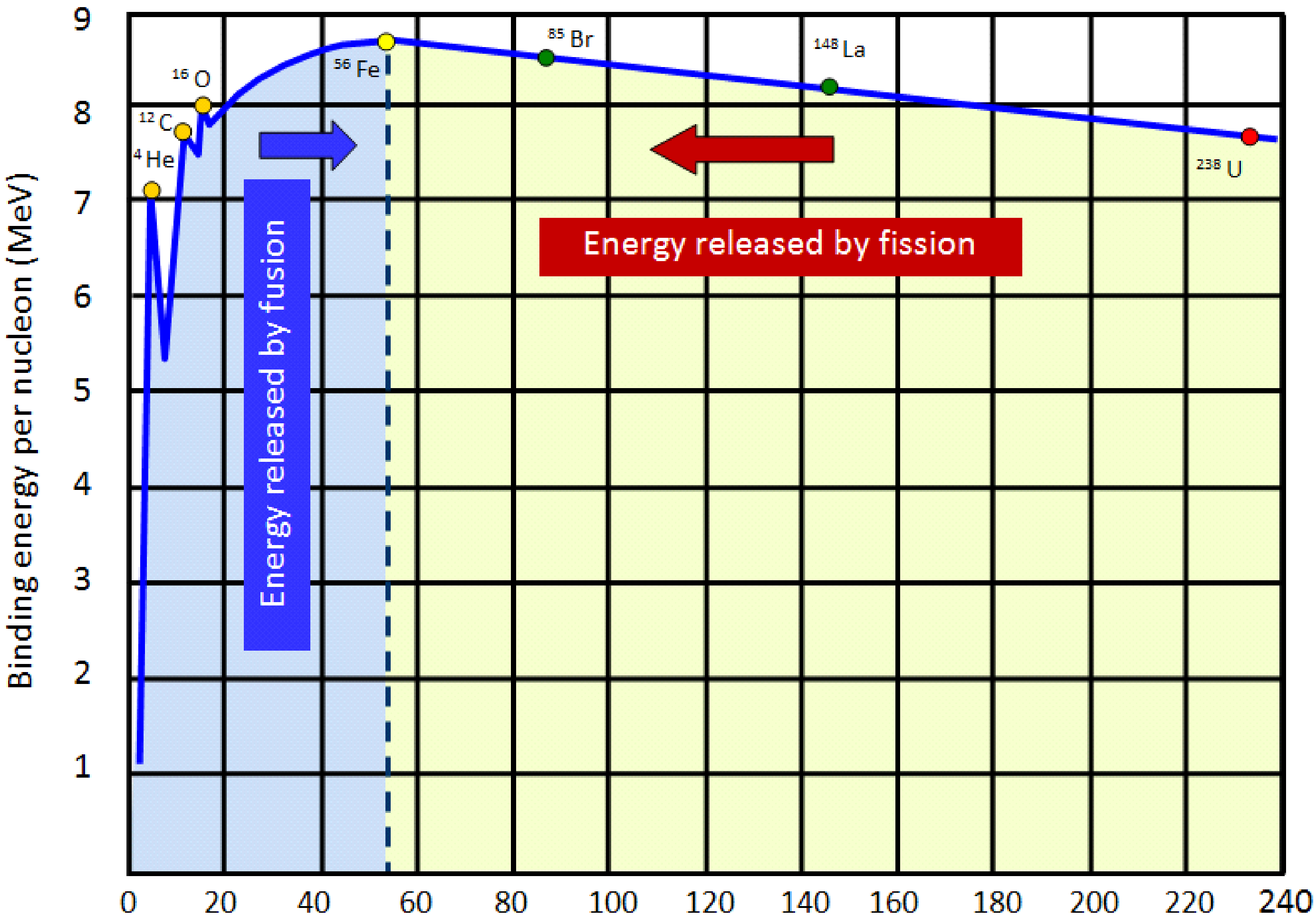

Figure 1

Iron 56 is the highest binding energy per nucleon, so it very stable. Higher Mass number nucleii are produced in SuperNova or other big energy cosmic events.

Determine the binding energy of Helium 4
isotopic mass = 4.002603u
proton = 1.007825u
neutron = 1.008665u

mass defect = 4.002603-((2x1.007825)+(2x1.008665))=-0.030377u

((2x1.007825)+(2x1.008665))=-0.030377u

binding energy = 0.030377x931.5=28.296176
28.30MeV

p642-645 Q1-8 CR 1.1-1.4
test for March 8th
quiz next Thursday March 2nd